Evaluation of Three Nematicides for the Control of Phytoparasitic Nematodes in ‘Tifgreen II’ Bermudagrass

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Abstract: Three nematicides were evaluated for control of Belonolaimus longicaudatus, Hoplolaimus galeatus, Criconemella spp., and Meloidogyne spp. in ‘Tifgreen II’ bermudagrass mowed at golf course fairway height (1.3 cm) in Fort Lauderdale, Florida. Bermudagrass plots were treated with fenamiphos (13.5 kg a.i./ha), oxamyl (13.5 kg a.i./ha), or 30% formaldehyde (6.4 liter a.i./ha). The plots treated with fenamiphos or formaldehyde were split 14 days later and one-half of each plot received two biweekly applications of formaldehyde. Forty-two days after the treatments were applied, the turfgrass vigor ratings and dry root weights in plots treated with fenamiphos were higher (P < 0.05) than the control, oxamyl, or formaldehyde treatments. The population levels of B. longicaudatus were suppressed (P < 0.05) in the fenamiphos, fenamiphos plus formaldehyde, and oxamyl treatments.

Key words: Belonolaimus longicaudatus, bermudagrass, chemical control, Criconemella spp., fenamiphos, formaldehyde, lance nematode, Hoplolaimus galeatus, Meloidogyne spp., oxamyl, ring nematode, root-knot nematode, sting nematode, turfgrass.

Warm-season turfgrasses, such as hybrid bermudagrass (Cynodon spp.), St. Augustinegrass (Stenotaphrum spp.), and bahia-grass (Paspalum spp.), grown on the coarse textured soils of southern Florida are susceptible to damage by phytoparasitic nematodes (2,7,9). Belonolaimus longicaudatus Rau, the sting nematode, is probably the most destructive and prevalent nematode parasite of bermudagrass (4,7,13) and other turfgrass species in Florida (9). Non-fumigant nematicides are the most common control agents for phytoparasitic nematodes attacking turfgrass (1,2,5-7,13). Few of these nematicides are highly effective for nematode control on turfgrass, and many of them are toxic to nontarget animals (7,8). Currently, there are only three nematicides labeled for nematode control on turfgrass in Florida: fenamiphos, ethoprop, and diazinon (2). Safe, effective materials, and expanded labels of effective compounds are needed for commercial and residential turfgrass. Our objective was to compare the efficacy of fenamiphos with oxamyl or formaldehyde for control of phytoparasitic nematodes in intensively managed bermudagrass.

MATERIALS AND METHODS

This study was conducted in May–June 1987 at the Fort Lauderdale Research and Education Center, Broward County, Florida, on ‘Tifgreen II’ bermudagrass (Cynodon dactylon × C. transvaalensis (Burt-Davy)), that was maintained under golf course fairway conditions. The study site was chosen because it was naturally infested with phytoparasitic nematodes that were relatively uniform in distribution. Pretreatment population densities (Pi) for B. longicaudatus, Hoplolaimus galeatus (Cobb) Thorne, Criconemella spp., and Meloidogyne spp. (juveniles and males) were not different (P > 0.05) within each species for all plots. The pooled means and standard deviations across treatments for the Pi of B. longicaudatus, Hoplolaimus galeatus (Cobb) Thorne, Criconemella spp., and Meloidogyne spp. were 165 ± 18, 102 ± 40, 626 ± 73, and 60 ± 11, respectively. The grass was mowed every other day at a 1.3-cm mowing height and all clippings were removed. Soil was classified as a Margate fine sand (siliceous, hyperthermic Mollic psammaquent); the surface horizon (upper 15 cm) contained 96% sand, 3% silt, 1% clay, 3% organic matter; pH 7.1. The saturated hydraulic conductivity at the site was 35.5 cm/hour and field capacity was...
0.08 cm³/cm³ (11). Treatments, random-
ized in five complete blocks, were fena-
miphos 10 G (13.5 kg a.i./ha), oxamyl 10 G (13.5 kg a.i./ha), 30% formaldehyde, (HD-Form-A-Turf, Hendrix and Dail, Greenville, NC) (6.4 liter a.i./ha), and a control. Plots were 0.8 × 1.9 m with a 20-
cm border. Formaldehyde was diluted 1:96 (v/v) in deionized water, and a pre-
measured volume was uniformly applied
with a plastic hand sprayer (Sprayco, De-
troit, MI). Fenamiphos and oxamyl were
broadcast uniformly over the plots with a
shaker can. Fenamiphos and formaldehyde
treated plots were divided in half 14 days
after initial treatment and one-half of each
plot was treated with two biweekly appli-
cations of formaldehyde at the same rate.
Treatments were applied before 1000
hours and 1.3 cm water was applied within
20 minutes of the application. Fertilizer
was applied 28 days after initial treatment
with 4.8 g N/m² in a 16-4-8 formulation
(N-P₂O₅-K₂O). Plots were irrigated with
approximately 7.5 mm water every other
day. Cumulative rainfall for this 42-day
study was 245 mm.

Turfgrass vigor ratings, based on per-
centage of ground cover and density of the
bermudagrass, were taken at the initiation
of the experiment and again at the end
(scale 1–10: 1 = bare ground, 5 = 50%
coverage and medium density, 10 = 100%
coverage and high density turfgrass). The
ratio of the final turfgrass vigor rating di-
vided by the initial rating for the different
treatments was used to assess changes in
plot performance. Phytotoxicity ratings
were made 1 and 2 weeks after each treat-
ment. Pooled root samples from six soil
cores (1.9 × 10 cm) were washed on two
nested sieves (openings of 1,700 and 850
µm) and all debris, leaves, stolons, and
thatch were removed. The roots were
weighed after oven drying at 60°C for 48
hours and again after ashing at 500°C for
24 hours.

Six soil cores (2.5 cm d and 10 cm deep)
were taken at random from each plot just
before treatment applications and 42 days
later. The samples were stored in plastic
bags and processed within 48 hours. Each
sample was thoroughly mixed, and nema-
todes were extracted and quantified from
a 100-cm³ subsample processed by a mod-
ified sugar flotation-centrifugation meth-
od (3). The modification involved dividing
each sample into four 50-ml tubes for sugar
flotation to decrease soil volume and in-
crease extraction efficiency per tube. All
fractions were recombined after process-
ing. The extracted volume was brought to
10 ml, and after mixing a 1-ml aliquot was
removed, diluted, and counted. The data
were subjected to analysis of variance, and
means separation was performed with a
Waller–Duncan k-ratio t-test at P < 0.05
and k = 100.

RESULTS AND DISCUSSION

The pretreatment turfgrass vigor rat-
ings averaged 7.1 ± 0.1 (range = 7.0–7.3)
with no differences observed between plots.
Bermudagrass ratings at the end of the ex-
periment were 0.7 units higher in plots
treated with fenamiphos and fenamiphos
plus formaldehyde than in plots treated
with oxamyl, formaldehyde, multiple ap-
plications of formaldehyde, and the con-
trol. The turfgrass rating ratio stayed close
to 1.0 (no change) in the fenamiphos-treat-
ment, whereas there was a decline in
turfgrass quality in the rest of the treat-
ments (Fig. 1A). No phytotoxicity (leaf
burning) was observed during the experi-
ment in any of the treatments. The fena-
miphos treatments resulted in a more than
25% dry root weight increase over the ox-
amyl, formaldehyde, multiple application
of formaldehyde, and control treatments
(Fig. 1B).

Belonolaimus longicaudatus population
densities (Pf) were suppressed (P < 0.05)
after 42 days in plots receiving fenami-
phos, fenamiphos plus formaldehyde, and
oxamyl (Fig. 2). All other nematode species
examined were not affected by any of the
treatments or treatment combinations. The
pooled means and standard deviations
across treatments for the Pf of H. galeatus,
Criconemella spp., and Meloidogyne spp. (ju-
veniles and males) were 114 ± 63, 669 ±
Fig. 1. Evaluation of Tifgreen II bermudagrass performance relative to nematicide treatment. A) Turfgrass performance ratio (final pretreatment) relative to treatment. B) Final dry root weight per six cores (1.9 x 10 cm) of soil relative to treatment. Treatments: N = fenamiphos 10 G at 13.5 kg a.i./ha; N + F = N + two biweekly applications of 30% formaldehyde at 6.4 liter a.i./ha; O = oxamyl 10 G at 13.5 kg a.i./ha; F = 30% formaldehyde at 6.4 liter a.i./ha; F + F = F + two biweekly applications of 30% formaldehyde at 6.4 liter a.i./ha. Error bar in up position; bars with the same letter are not different based on a Waller-Duncan k-ratio t-test (P > 0.05).

Fig. 2. Comparison of Belonolaimus longicaudatus population densities per 100 cm³ soil before and 42 days after nematicide treatment. Error bar in up position; bars with the same capital letter are not different based on Waller-Duncan k-ratio t-test comparisons (P > 0.05); bars with the same lower case letters are not different based on Waller-Duncan k-ratio t-test comparisons (P > 0.05).

142, and 58 ± 20, respectively. The Pf of B. longicaudatus was negatively correlated with final visual ratings (r = -0.41, P = 0.025) and dry root weight at harvest (r = -0.51, P = 0.004). The dry root weight at harvest was positively correlated with the ratio of final pretreatment vigor ratings (r = 0.53, P = 0.003) and final ratings of bermudagrass vigor (r = 0.45, P = 0.014). No correlations existed for the other nematodes surveyed.

Fenamiphos at 11.2 kg a.i./ha gave a fourfold increase in dry root weight and more than a 3.0 turfgrass rating increase (scale = 1-10) in 6 months in 'Ormond' bermudagrass infested with B. longicauda-
tus (7). Turfgrass quality ratings and the number of B. longicaudatus were negatively correlated for up to a year after treatment with 21.5 kg a.i./ha of fenamiphos (5). Fenamiphos, fenamiphos sulfoxide, and fenamiphos sulfone soil residues at 2.5–10 cm peaked at 7 or 30 days and declined to low levels by 60 days in a golf-green experiment in California (8). Different soil types, nematicide rates, mowing heights, history of soil conditioning to pesticides, cultural practices, weather, and subjectivity in the rating system between observers could all affect the turfgrass visual rating divergence between our study and others. We observed significant dry root weight differences in only 42 days, which suggests that fenamiphos affects nematode damage on roots, or stimulates root growth by itself, or both.

Oxamyl was tested in this experiment because it has systemic activity and has some activity against phytoparasitic nematodes in range grasses (10,12). It is not currently labeled for turfgrass; if efficacious, however, it would provide another management option. We applied oxamyl at 13.5 kg a.i./ha because this was the highest cost-effective rate relative to the fenamiphos commercial standard. There was some suppression of B. longicaudatus by oxamyl,
relative to the control and formaldehyde treatments (Fig. 2), but no concomitant increase was observed in turfgrass quality (Fig. 1A, B). Formaldehyde was tested because of preliminary in vitro evidence that it was toxic to *B. longicaudatus* at the concentration tested (unpubl.). The formulation evaluated did not control nematodes when applied alone or in multiple applications, and it did not improve the performance of fenamiphos when applied over it (Figs. 1, 2).

Although the pretreatment turfgrass vigor ratings of bermudagrass were above 7, the densities of *B. longicaudatus* were more than 16 times the estimated threshold that justifies control measures (2). In addition, *H. galeatus*, *Criconemella* spp., and *Meloidogyne* spp. were above estimated threshold levels. These inconsistencies suggest the need for refinement of the damage functions for different nematode species in turfgrasses and the need for a better understanding of the nature of poly-specific nematode communities (4).

**LITERATURE CITED**


